Claims:

1. A piezoelectric element comprising:

a ceramic substrate,

a piezoelectric portion made of a piezoelectric ceramic composition containing a $PbMg_{1/3}Nb_{2/3}O_3$-$PbZrO_3$-$PbTiO_3$ ternary system solid solution composition having an average particle diameter of 1 – 10 μm with a maximum particle diameter being 5 times as large as the average particle diameter or less and being represented by the following general formula (1) as a main component and 0.05 to 10.0 mass% of NiO, and

an electrode;

wherein said electrode is electrically connected to said piezoelectric portion, and said piezoelectric portion is solidly attached to the ceramic substrate directly or via said electrode.

$$Pb_x(Mg_{y/3}Nb_{2/3})_aTi_bZr_cO_3 \qquad (1)$$

wherein $0.95 \leqq x \leqq 1.05$; $0.8 \leqq y \leqq 1.0$; a, b and c are decimals falling in a range surrounded by (a,b,c) = (0.550, 0.425, 0.025), (0.550, 0.325, 0.125), (0.375, 0.325, 0.300), (0.100, 0.425, 0.475), (0.100, 0.475, 0.425) and (0.375, 0.425, 0.200) in the coordinates with coordinate axes of said a, b and c, and a+b+c = 1.00.

2. A piezoelectric element comprising:

a ceramic substrate,

a plurality of piezoelectric portion made of a piezoelectric ceramic composition containing a $PbMg_{1/3}Nb_{2/3}O_3$-$PbZrO_3$-$PbTiO_3$

ternary system solid solution composition represented by the following general formula (1) as a main component and 0.05 to 10.0 mass% of NiO, and

a plurality of electrodes;

wherein said plurality of piezoelectric portion are laminated with interposing negative electrodes and positive electrodes of said electrodes alternately in each gap between said piezoelectric portions and a lowermost piezoelectric portion is solidly attached to the ceramic substrate directly or via said electrode.

$$Pb_x(Mg_{y/3}Nb_{2/3})_aTi_bZr_cO_3 \qquad (1)$$

wherein $0.95 \leqq x \leqq 1.05$; $0.8 \leqq y \leqq 1.0$; a, b and c are decimals falling in a range surrounded by (a,b,c) = (0.550, 0.425, 0.025), (0.550, 0.325, 0.125), (0.375, 0.325, 0.300), (0.100, 0.425, 0.475), (0.100, 0.475, 0.425) and (0.375, 0.425, 0.200), in the coordinates with coordinate axes of said a, b and c, and a+b+c = 1.00.

3. A piezoelectric element according to Claim 2, wherein said ternary system solid solution composition has an average particle diameter of 1 – 10 μm with a maximum particle diameter being 5 times as large as the average particle diameter or less.

4. A piezoelectric element comprising:

a ceramic substrate,

a piezoelectric portion made of a piezoelectric ceramic composition containing a $PbMg_{1/3}Nb_{2/3}O_3$-$PbZrO_3$-$PbTiO_3$ ternary

system solid solution composition represented by the following general formula (1) as a main component and 0.05 to 10.0 mass% of NiO, and said piezoelectric ceramic composition contain particles having NiO as a main component on the surface and/or in the interior thereof, and

an electrode;

wherein said electrode is electrically connected to said piezoelectric portion, and said piezoelectric portion is solidly attached to the ceramic substrate directly or via said electrode.

$$Pb_x(Mg_{y/3}Nb_{2/3})_aTi_bZr_cO_3 \qquad (1)$$

wherein $0.95 \leqq x \leqq 1.05$; $0.8 \leqq y \leqq 1.0$; a, b and c are decimals falling in a range surrounded by (a,b,c) = (0.550, 0.425, 0.025), (0.550, 0.325, 0.125), (0.375, 0.325, 0.300), (0.100, 0.425, 0.475), (0.100, 0.475, 0.425) and (0.375, 0.425, 0.200), in the coordinates with coordinate axes of said a, b and c, and a+b+c = 1.00.

5. A piezoelectric element according to Claim 4, wherein said ternary system solid solution composition has an average particle diameter of 1 – 10 μ m with a maximum particle diameter being 5 times as large as the average particle diameter or less.

6. A piezoelectric element according to Claim 4, wherein said particles having NiO as a main component is obtained by subjecting MgO to a solid solution treatment.

7. A piezoelectric element according to Claim 1, wherein Ni is dispersed in said piezoelectric ceramic composition in such a

concentration gradient that the concentration of Ni becomes higher from the interface between said piezoelectric portion and said substrate towards the thickness direction of the piezoelectric portion.

8. A piezoelectric element according to Claim 2, wherein Ni is dispersed in said piezoelectric ceramic composition in such a concentration gradient that the concentration of Ni becomes higher from the interface between said piezoelectric portions and said substrate towards the thickness direction of the piezoelectric portions.

9. A piezoelectric element according to Claim 4, wherein Ni is dispersed in said piezoelectric ceramic composition in such a concentration gradient that the concentration of Ni becomes higher from the interface between said piezoelectric portion and said substrate towards the thickness direction of the piezoelectric portion.

10. A piezoelectric element according to Claim 1, wherein Pb in said piezoelectric ceramic composition is replaced by at least one kind of element selected from the group consisting of Sr, Ca and Ba, by 2 to 10 mole % in the whole Pb.

11. A piezoelectric element according to Claim 2, wherein Pb in said piezoelectric ceramic composition is replaced by at least one kind of element selected from the group consisting of Sr, Ca and Ba, by 2 to 10 mole % in the whole Pb.

12. A piezoelectric element according to Claim 4, wherein Pb

in said piezoelectric ceramic composition is replaced by at least one kind of element selected from the group consisting of Sr, Ca and Ba, by 2 to 10 mole % in the whole Pb.

13. A piezoelectric element according to Claim 1, wherein Pb in said piezoelectric ceramic composition is replaced by La by 0.2 - 1.0 mole % in the whole Pb.

14. A piezoelectric element according to Claim 2, wherein Pb in said piezoelectric ceramic composition is replaced by La by 0.2 - 1.0 mole % in the whole Pb.

15. A piezoelectric element according to Claim 4, wherein Pb in said piezoelectric ceramic composition is replaced by La by 0.2 - 1.0 mole % in the whole Pb.

16. A piezoelectric element according to Claim 1, wherein said piezoelectric portion has a thickness of 1 to 300 μm.

17. A piezoelectric element according to Claim 2, wherein said piezoelectric portions have a thickness of 1 to 300 μm.

18. A piezoelectric element according to Claim 1, wherein said piezoelectric portion has a thickness of 1 to 300 μm.

19. A piezoelectric element according to Claim 1, wherein said substrate has a thickness of 3 μm to 1 mm.

20. A piezoelectric element according to Claim 2, wherein said substrate has a thickness of 3 μm to 1 mm.

21. A piezoelectric element according to Claim 4, wherein said substrate has a thickness of 3 μm to 1 mm.

22. A piezoelectric element according to Claim 1, wherein the

ratio of the thickness of the substrate to the thickness of the piezoelectric portion (the thickness of the substrate / the thickness of the piezoelectric portion) is 0.1 to 30.

23. A piezoelectric element according to Claim 2, wherein the ratio of the thickness of the substrate to the thickness of the piezoelectric portions (the thickness of the substrate / the thickness of the piezoelectric portions) is 0.1 to 30.

24. A piezoelectric element according to Claim 4, wherein the ratio of the thickness of the substrate to the thickness of the piezoelectric portion (the thickness of the substrate / the thickness of the piezoelectric portion) is 0.1 to 30.

25. A piezoelectric element according to Claim 1, wherein a cross-section of said substrate in the thickness direction has a W-like shape having three inflection points.

26. A piezoelectric element according to Claim 2, wherein a cross-section of said substrate in the thickness direction has a W-like shape having three inflection points.

27. A piezoelectric element according to Claim 4, wherein a cross-section of said substrate in the thickness direction has a W-like shape having three inflection points.

28. A method for producing a piezoelectric element comprising the steps of:

superposing a piezoelectric material made of a piezoelectric ceramic composition containing a $PbMg_{1/3}Nb_{2/3}O_3$-$PbZrO_3$-$PbTiO_3$ ternary system solid solution composition

represented by the following general formula (1) as a main component and 0.05 to 10.0 mass% of NiO on a ceramic substrate or on an electrode formed on the ceramic substrate, and

subjecting the superposed piezoelectric material to a thermal treatment in an atmosphere where 0.03 – 0.5 mg/cm^3 (NiO conversion amount per unit volume of a space in a container) of a atmosphere-controlling material having the same composition as the piezoelectric material is coexisted.

$$Pb_x(Mg_{y/3}Nb_{2/3})_aTi_bZr_cO_3 \qquad (1)$$

wherein $0.95 \leqq x \leqq 1.05$; $0.8 \leqq y \leqq 1.0$; a, b and c are decimals falling in a range surrounded by (a,b,c) = (0.550, 0.425, 0.025), (0.550, 0.325, 0.125), (0.375, 0.325, 0.300), (0.100, 0.425, 0.475), (0.100, 0.475, 0.425) and (0.375, 0.425, 0.200), in the coordinates with coordinate axes of said a, b and c, and a+b+c = 1.00.

29. A method for producing a piezoelectric element comprising the steps of:

superposing a piezoelectric material made of a piezoelectric ceramic composition containing a $PbMg_{1/3}Nb_{2/3}O_3$-$PbZrO_3$-$PbTiO_3$ ternary system solid solution composition represented by the following general formula (1) as a main component and 0.05 to 10.0 mass% of NiO on a ceramic substrate or on an electrode formed on the ceramic substrate, and

subjecting the superposed piezoelectric material to a thermal treatment in an atmosphere;

wherein 0.03 – 0.5 mg/cm^3 (NiO conversion amount per

unit volume of a space in a container) of an atmosphere-controlling material having the same composition as the piezoelectric material is coexisted as a container for housing said electrode on which the piezoelectric material is superposed and a setter for mounting the piezoelectric material thereon.

$$Pb_x(Mg_{y/3}Nb_{2/3})_aTi_bZr_cO_3 \qquad (1)$$

wherein $0.95 \leqq x \leqq 1.05$; $0.8 \leqq y \leqq 1.0$; a, b and c are decimals falling in a range surrounded by (a,b,c) = (0.550, 0.425, 0.025), (0.550, 0.325, 0.125), (0.375, 0.325, 0.300), (0.100, 0.425, 0.475), (0.100, 0.475, 0.425) and (0.375, 0.425, 0.200), in the coordinates with coordinate axes of said a, b and c, and a+b+c = 1.00.